

# Thermal Material Selection in Small Satellite Interfaces to Optimize Cost, Performance and Assembly Time



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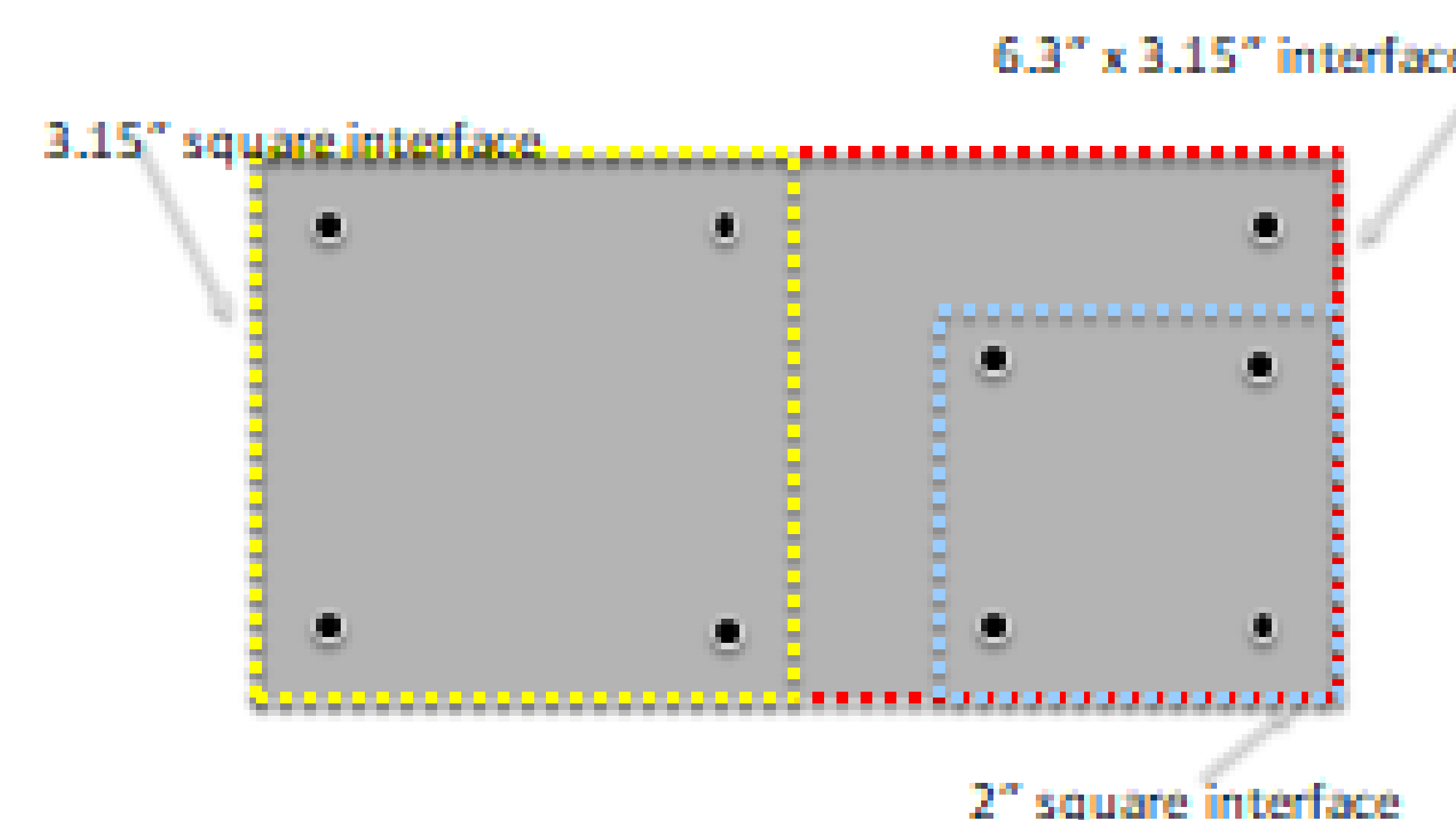
## Motivation: Interface material selection is costly and inefficient

- Data sheets give generic material properties like thermal conductivity, thickness, and compression that don't actually tell you how the material will perform in application
- After basic material evaluation, testing is required for each new application to understand how the product will perform in application (time consuming and expensive)
- Even after qualification, maintaining multiple solution types (liquid, cured in place, dry gaskets makes inventory management)
- Traditional solutions have built in weaknesses that have plagued builds for years:
  - Cured solutions takes days to install and are difficult to rework
  - Thick dry pads distort interfaces when compressed, resulting in stressed components and potted insert pull out
  - Liquid solutions (greases and gels) can pump out of interfaces over time resulting in unexpected failures

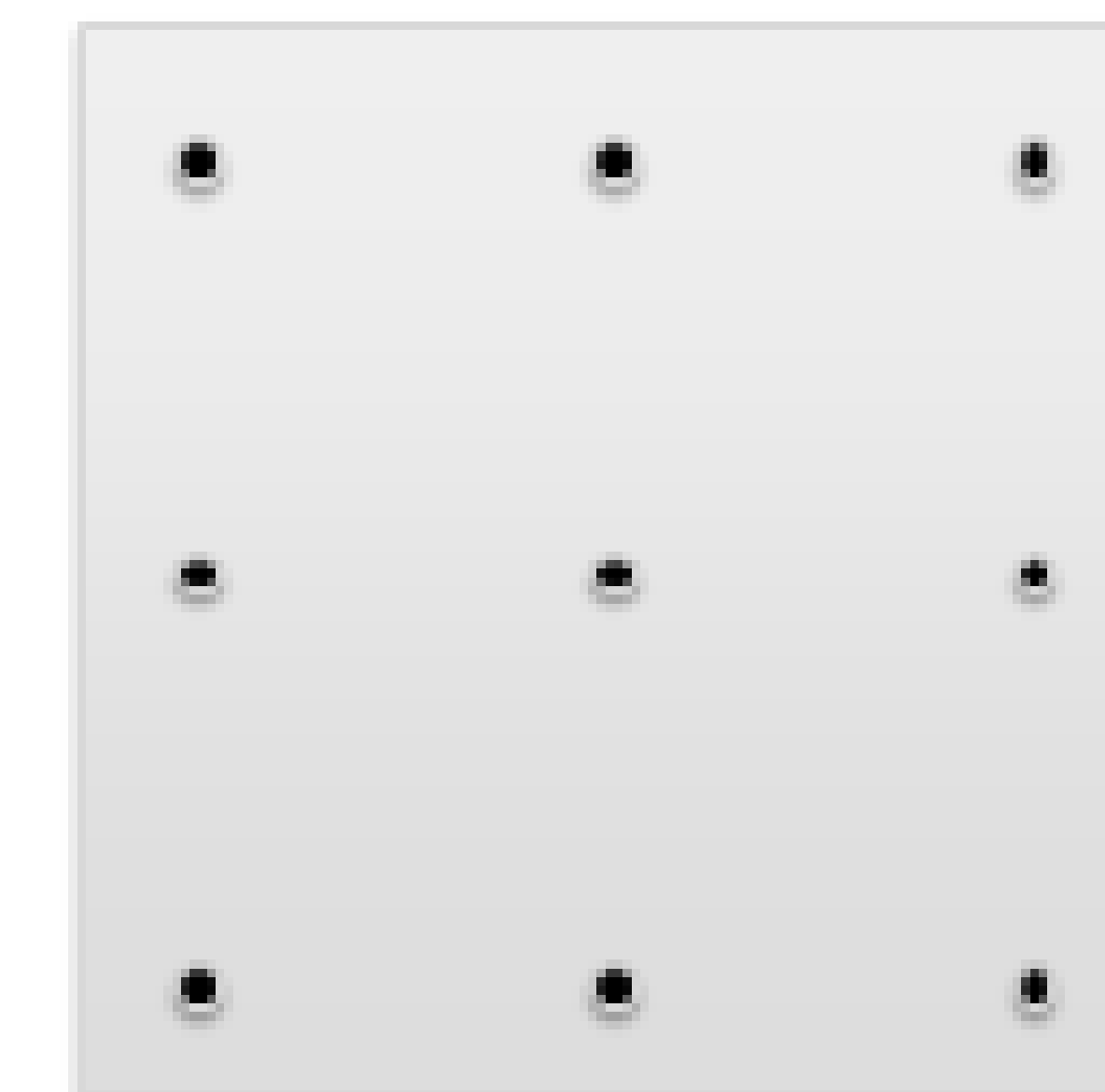
**Goal:** Predictive Modeling is needed to enable interface analysis and selection without application specific testing for each design

**Approach:** Performance data collected on over 200 combinations of Carbice® interface types and solution forms to develop an empirical model that can predict performance of thermal gaskets in real applications

6.3"x 3.15" interface accommodates various plate sizes and bolt configurations



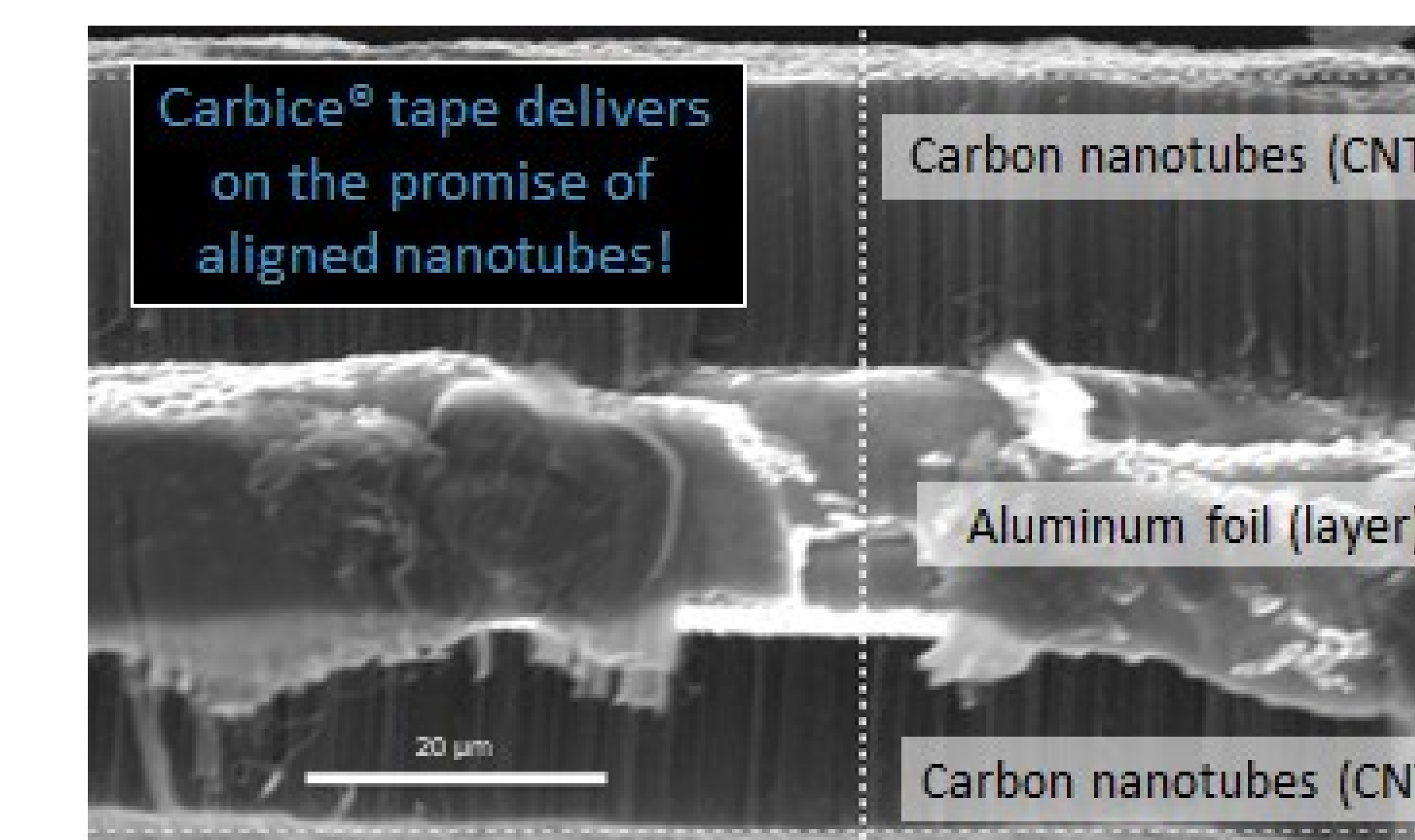
7" x 7" interface 4, 5 or 8 bolts



### Test Information

- Plate Sizes: 2" x 2", 6.3" x 3.15", 7" x 7"
- Over 50 combinations of bolt spacing and torques evaluated
- Gasket thicknesses ranged from 65 µm to 245 µm

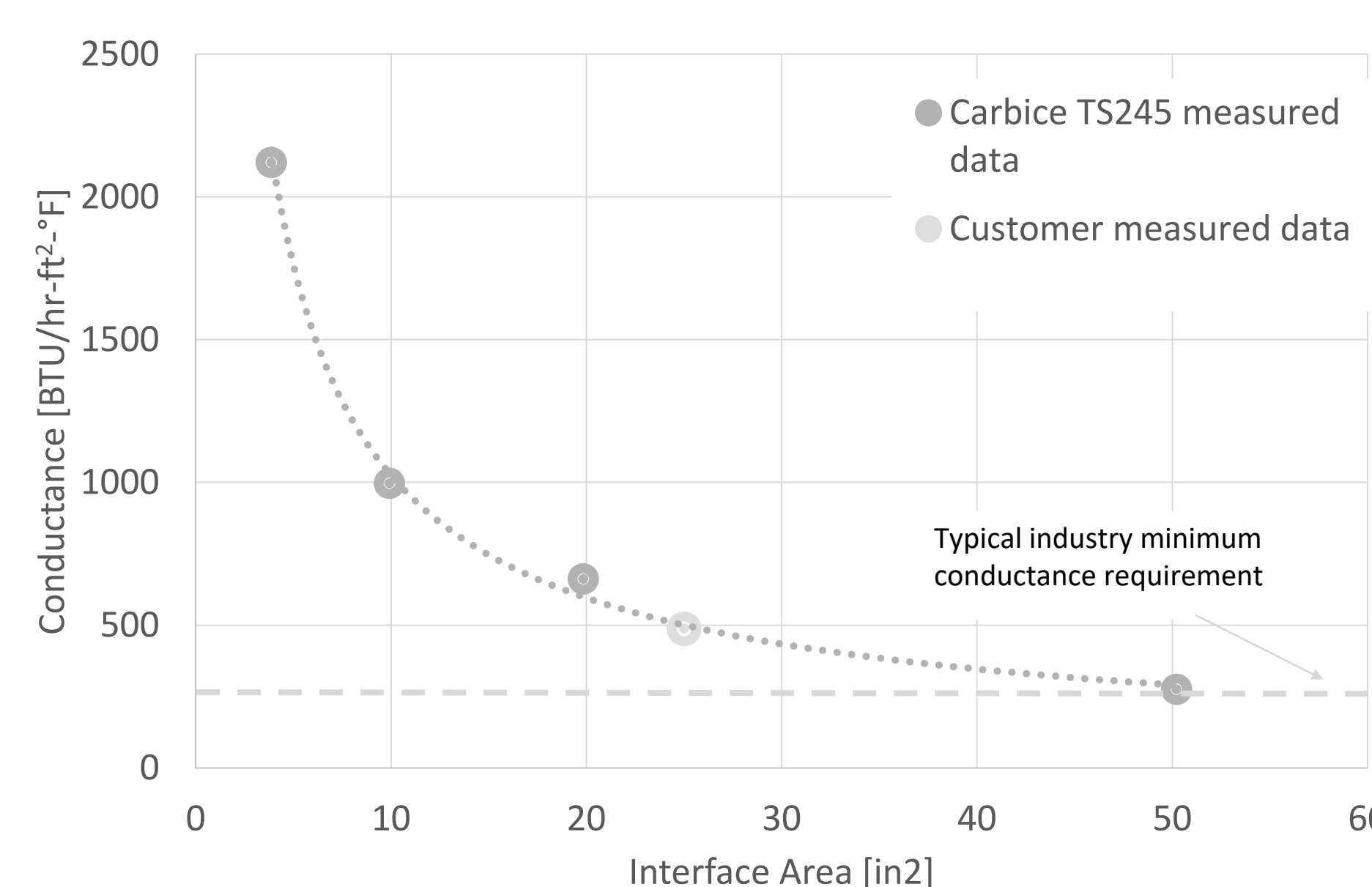
## Carbice® Thermal Interface Solution



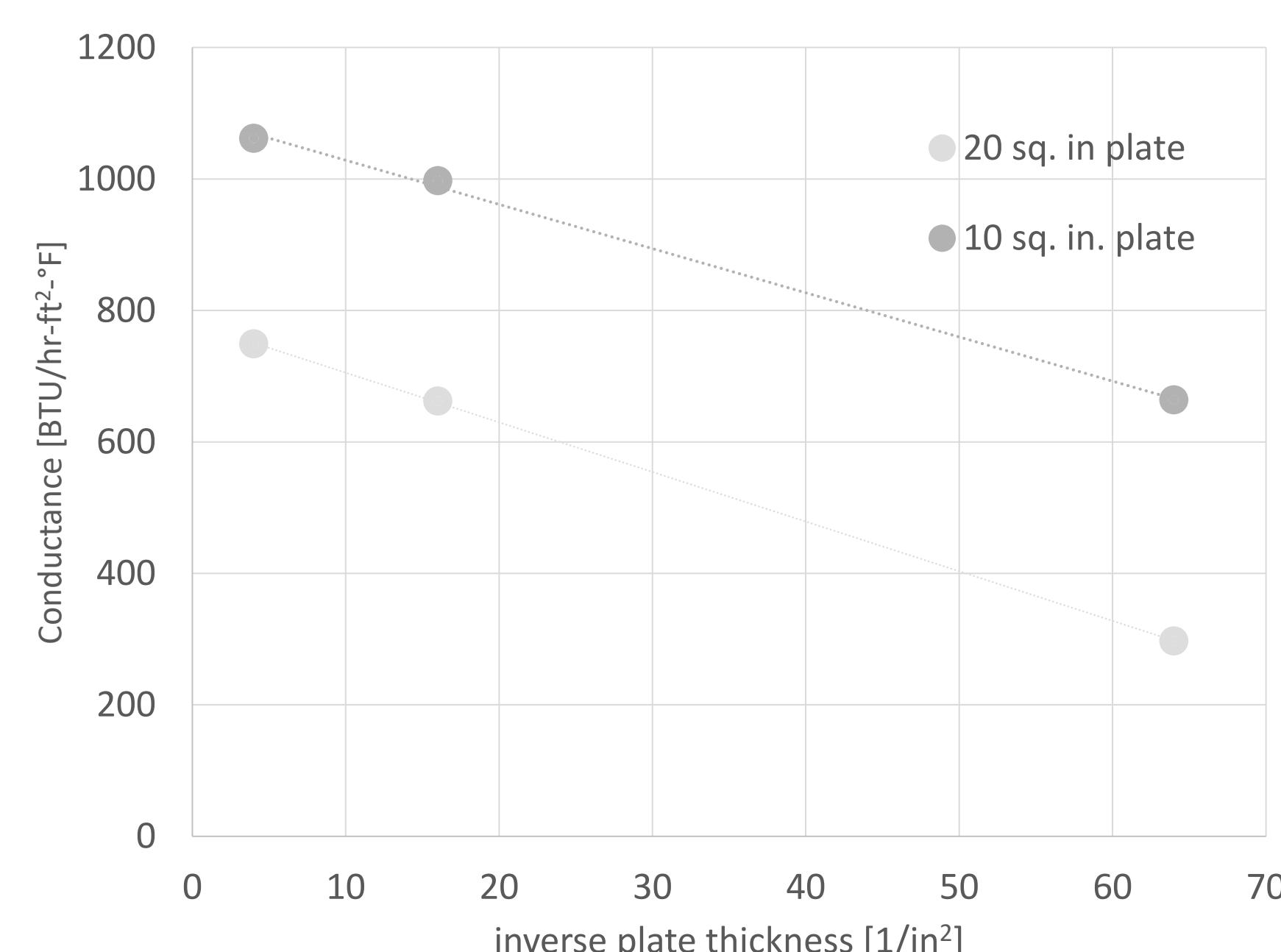
- Carbice Tape delivers **3,000 W/m-K** Carbon Nanotube Technology in a product form that can address all types of applications in a single product form
- Tunable thickness and breakthrough mechanics (can be compressed over 50% with no compression set)
- Patented polymer encapsulation technology enables robust solution with optional adhesive with no thermal penalty for easy integration

## Results

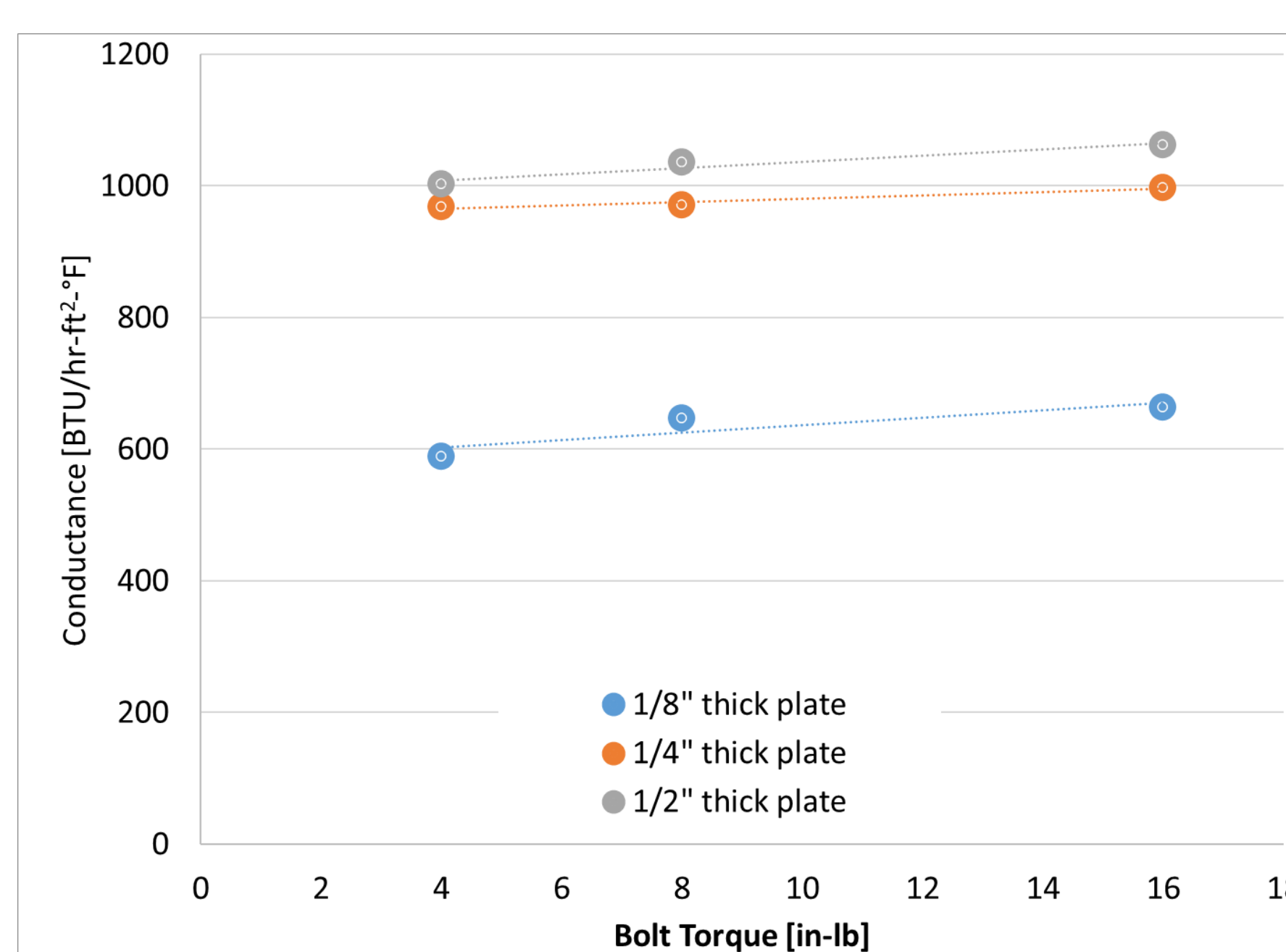
TS245 projected and measured performance: 4 perimeter bolts



Relationship between conductance and plate thickness



Relationship between conductance and bolt torque for 3.15" square plates



Interface	Interface Area [cm²]	# of bolts	Model Predicted Performance [W/m²-C]	Measured TVAC performance [W/m²-C]	Model Accuracy	Notes
Customer test rig: 5" x 5" bolted joint	161	4	2,636	2,761	5%	Simple square test rig
Customer mock: traveling Wave Tube Amplifier	77	8	10,596	10,309	-3%	
Customer Application: Low Noise Amplifier	78	7	10,881	10,399	-4%	Square plate with 2 internal cavities. 3 perimeter bolts/ 4 center bolts
Customer application: Low Noise Amplifier #2	91	8	7,393	6,237	-16%	Rectangular part with large cavity in center. All bolts on perimeter
Customer application: LNA #2 modified bolt pattern	91	4	4,170	3,504	-16%	
Customer test rig: 4" x 4" bolted joint	100	4	5,692	5,933	4%	Simple square test rig

**Conductance(A, # bolts, plate thickness, torque)**

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**Empirical model predicts the performance of real bolted interfaces in vacuum within 20%**